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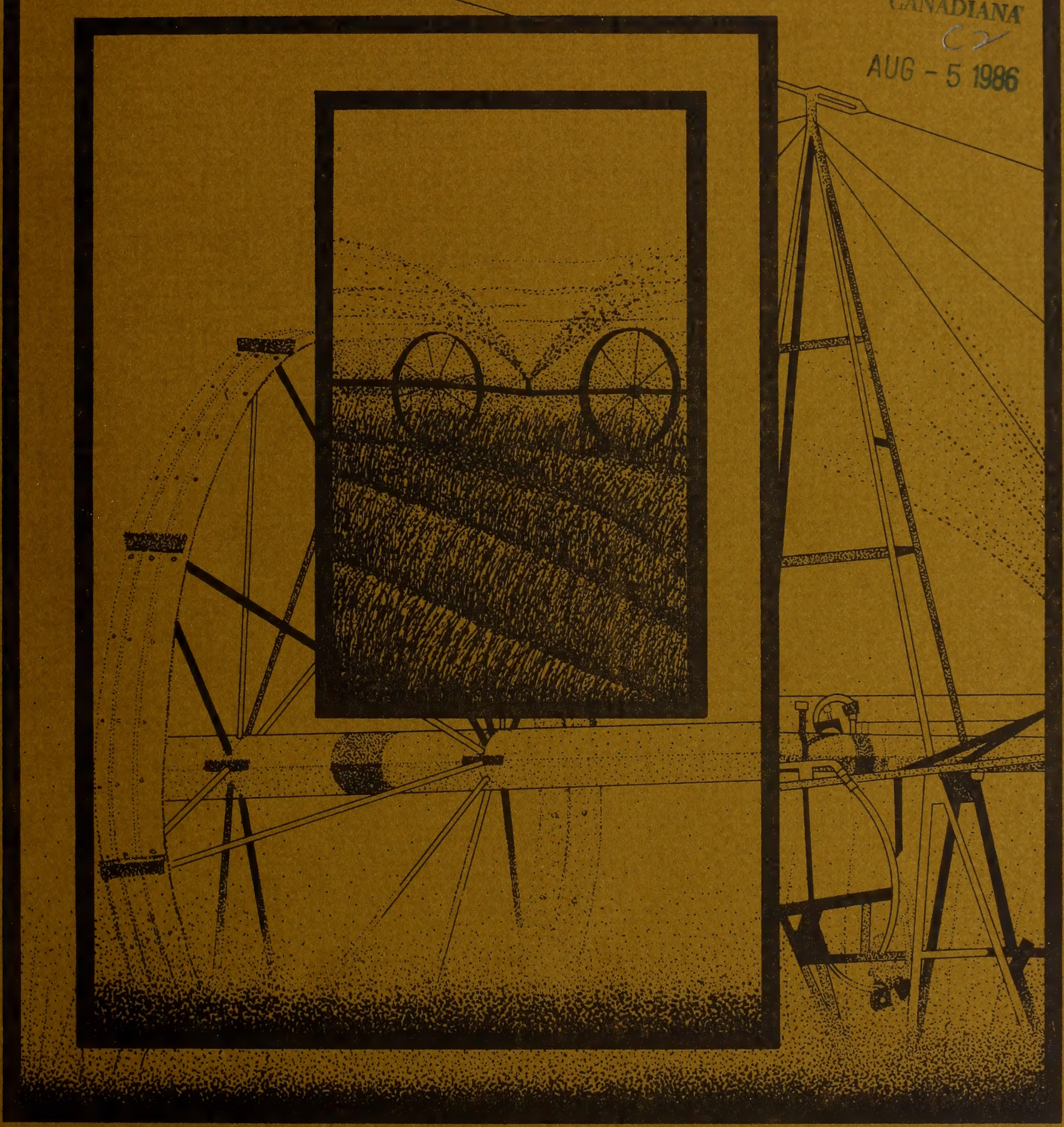
Irrigated Canola Production



Alberta
AGRICULTURE
Field Crops Branch

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IRRIGATED CANOLA PRODUCTION

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Phil Thomas
Supervisor, Oilseed Crops
Field Crops Branch
Alberta Agriculture
Bag Service #47
Lacombe, Alberta
T0C 1S0

Keith Topinka
Canola Researcher
Alberta Agriculture
Agriculture Center
Lethbridge, Alberta
T1J 4C7

Robert Riewe
Irrigation Management Specialist
Irrigation Branch
Alberta Agriculture
Agriculture Center
Lethbridge, Alberta
T1J 4C7

IRRIGATED CANOLA PRODUCTION

INTRODUCTION

The objective of this manual is to provide growers with information that will help them maximize irrigated canola production for the greatest dollar return per unit area grown. High canola production is dependent upon soil, climate, and plant and management practices. Each crop production practice will affect crop growth within the system. While some crop production factors have a greater influence on yield than others, it is important that they all be in balance.

The information presented in this manual is a composite of the latest research and grower management practices. The manual covers basic crop production factors and their integration into a crop production system. To help learn which successful production practices are being employed by top canola growers, Alberta Agriculture, assisted by Canbra Foods Ltd. of Lethbridge, conducted a survey of 34 above-average growers during the winter of 1985-86. The growers were individually selected to answer questions dealing with all aspects of their 1985 irrigated canola production practices. The data were compiled and analyzed, showing trends in production practices by the top growers. The survey information is mainly subjective but clear trends are indicated when large percentage differences occur.

The producers surveyed achieved an average yield of 48 bushels per acre, with yields ranging from 30 to 69 bu/acre. This was considerably higher (38%) than the provincial average for irrigated canola, estimated at 35 bu/acre. No one production factor automatically resulted in the higher yields. It was a combination of many factors, each contributing in a small or large way to an overall large yield increase. The growers who consistently

obtained high yields paid careful attention to practices which met the crop's requirements for maximum growth at all of its growth stages. Readers are challenged to compare their production practices with those of the top growers.

Characteristics of the survey sample

Number of producer survey returns	**34**
Average Years of Experience Growing Irrigated Canola	**%**
3 or less	37
3 to 5	15
5 to 10	33
10 to 15	12
15 or more	3

Average Number of Cultivated and Canola Acres per Farm:

Cultivated	%	Canola	%
200 or less	6	50 or less	6
200 to 500	24	50 to 100	36
500 to 1,000	24	100 to 200	34
1,000 to 3,000	37	200 to 500	12
3,000 to 5,000	3	500 to 1,000	3
5,000 or more	6	1,000 to 3,000	3

Percent of Growers Practising Continuous Cropping **100%**

Districts covered by the survey were: Brooks, Vauxhall, Taber, Bow Island, Warner, Lethbridge, Magrath, Raymond, Carmangay and Medicine Hat.

Soil Types Involved in the Survey:	**%**
Brown	73
Dark Brown	27

Soil Textures of the Fields in the Survey:	**%**
Sandy	3
Sandy loam	27
Sandy clay loam	37
Loam	6
Clay loam	24
Clay	3

The growers in the survey all practised continuous cropping and represented all the major irrigation areas, soil types and textures of southern Alberta. There was a wide range in farm size, average canola acreage per farm, and experience in growing canola amongst these top growers.

CANOLA VARIETIES

Canola varieties grown in Alberta belong to either the *Brassica napus* (Argentine type) or *Brassica campestris* (Polish type) species, which in turn belong to the much larger mustard family. Canola is closely related to turnip, rutabaga, cabbage, cauliflower, kale, and brown and oriental mustard. Canola is more distantly related to many cruciferous weeds such as mustard, stinkweed, flixweed and shepherd's purse. These weed in canola are therefore hard to control with herbicides.

The *B. napus* and *B. campestris* varieties have distinct agronomic characteristics which should be considered when selecting a variety to grow. The variety you select should meet the requirements of your own particular farming practices, timing of farming operations, and growing season climate.

Seed yields and agronomic characteristics vary not only between species but between varieties. Varieties may respond differently to rainfall, irrigation, frost-free periods, and climatic conditions. The yield performance of the licensed canola varieties under irrigation yield tests are as follows:

Comparison of Canola Varieties Under Irrigation

Variety	Yield as % of Tobin	Days to Maturity	Lodging 1 = nil 5 = severe	Height cm
Westar	120	98	3.2	110
Pivot	125	103	2.2	135
Regent	110	101	3.1	115
Triton	80	103	3.4	110
Tobin	100	86	2.4	95

The *B. napus* varieties, Westar and Pivot, and the *B. campestris variety*, Tobin, were consistently the best in each species. Westar is earlier maturing and shorter than Pivot; however, lodging can be a problem in high-yielding fields. Pivot, licensed in 1985 for irrigation in southern Alberta, is later maturing than Westar so early planting is recommended. Pivot is best grown under a centre pivot or flood irrigation system as its greater height can block a wheel move during flowering and early seed set. An obvious advantage of Pivot over Westar is its exceptional lodging resistance. The new triazine-tolerant varieties, Triton and Tribute, are significantly lower yielding, contain less oil in

the seed, and lodge more than other varieties. Tribute matures in the same time to Westar, while Triton is four or more days later. The seedlings of these varieties exhibit poor vigor and compete poorly against weeds and insect pests. Therefore careful seedbed preparation is required for a successful stand. Triton and Tribute should only be used where serious problems with cruciferous weeds such as wild mustard and stinkweed are expected, or in a corn rotation where atrazine herbicides have been used. Global, a new variety licensed in 1985 for eastern Canada, has met or exceeded Westar's yield in two years of testing at Lethbridge. This variety is similar to Pivot in maturity, height, and lodging resistance, and may be recommended in the future after further testing.

The *B. campestris* variety, Tobin, generally yields 20 per cent less than Westar. Tobin matures about two weeks earlier, shatters less readily when ripe, has shorter plants and less lodging than Westar. Because of these characteristics, Tobin is more easily irrigated by wheel move systems than Westar or Pivot which may be limited by their height.

Growers in the survey achieved reasonably high yields with the licensed varieties they grew.

Variety	Growers (%)	Yield Range (bu/ac)	Avg. Yield (bu/ac)
Westar	79	32 - 69	47
Pivot	15	49 - 67	58
Tobin	6	30 - 46	38
Survey	100	30 - 69	48

Only 15 per cent of the survey growers grew Pivot, however, their experience with this new variety can be compared with the 79 per cent who grew Westar. Pivot growers averaged 10 years' experience growing canola compared with 5 years' experience for Westar growers. These veteran growers achieved Pivot yields ranging from 49 to 67 bu/acre with an average of 58 bu/acre. Westar also reached a high of 69 bu/acre; however, the greater range in yields from 32 to 69 brought the average to 47 bu/acre. This demonstrates that both varieties are capable of high yields. When new varieties are offered, most top growers wait one year before trying them. They then purchase enough certified seed for 50 to 75 per cent of their canola acres and try the variety for one to two years before making a decision as to its adaptability on their farm. The growers who achieved the highest yields in 1985 also had the highest average yields for the previous five years.

Westar matured 10 days earlier on average than Pivot (100 vs 110 days); however, maturity ranges were large with Westar at 85 to 122 days and Pivot 100 to 120 days.

Westar averaged 4.5 feet in height and ranged from 3 to 6 feet, while Pivot averaged 10 inches taller than Westar with a similar range in height. Pivot was only grown under centre pivot systems which was a sensible choice because of the variety's height. Westar was grown equally under centre pivot and wheel move systems, and 15 per cent under flood irrigation.

All Pivot growers felt that lodging resistance was important in selecting a variety. Lodging of Pivot ranged from light to moderate while Westar ranged from none to 20 per cent severe. As Westar gets taller, it tends to lodge more. Fortunately the yields also increased with height.

Plant Height (feet)	Average Yield (bu/acre)
3 to 4	40
4 to 5	47
5 to 6	54

Neither variety had much yield loss before or during swathing. Loss due to diseases was also rated low (less than 3%). After swathing Westar stubble ranged from 4 to 20 inches, averaging 12 inches, while Pivot stubble ranged from 15 to 20 inches, indicating it could be cut much higher to ease harvest.

GROWTH STAGES OF THE CANOLA PLANT

A grower who has an understanding of how a canola plant grows, and how its pattern of growth can be affected by what he does, can make more effective management decisions. The growth stages are as follows:

Stage 1 (Seedling): Following germination the seedling emerges about four to 10 days after seeding with a short stem and two cotyledons or seed leaves. Unlike barley, which keeps its growing point protected beneath the soil for five to six weeks, the growing point of canola is above the soil between the two cotyledons. The exposed growing tip makes canola seedlings more susceptible than cereal grains to spring frosts, soil drifting, insects

and hail, or any other hazard which results in destruction of the seedling stem below the cotyledons.

Stage 2 (Rosette): Four to eight days after emergence, the seedling develops its first two leaves. The leaves play a major role in canola plant growth. Rapid leaf development and growth allow the plant to collect more sunlight, encourage root growth, reduce soil moisture evaporation and will shade weeds. The larger the leaf area, the larger the plant will grow, and the greater its seed yield.

Stage 3 (Bud): After forming from three to six leaves in the rosette stage, the plant "bolts" or rapidly sends up its stem with a cluster of flower buds at the top. Secondary branches also begin growing with flower bud clusters. The days from seeding to the end of the bud stage or first flower range from 30 to 50 days in *B. campestris*, and 40 to 60 days in *B. napus*, depending on the date of seeding and growing conditions.

Stage 4 (Flowering): Flowering begins with the opening of the lowest bud on the main stem and continues upward with three to five, or more, flowers opening per day. Full height is reached at peak flowering. Under reasonable conditions, flowering on the main stem will continue from 14 to 28 days for both species. Rapid uniform emergence, and the development of a large leaf area which is maintained beyond the start of flowering, is important for high seed set and yields, and can be promoted by proper seedbed preparation, timely planting, and adequate moisture and nutrients. Canola plants produce more buds and flowers than can develop into productive pods. Normally, only 40 to 55 per cent of the flowers produced on a plant develop productive pods that are retained until harvest. Most of the productive pods are from flowers which open within 15 days of flowering on the main stem and first few secondary branches. Later flowers and pods usually abort. Lack of nutrients or water, weed competition, and insect and/or disease damage affect the numbers of productive pods formed at this stage.

Stage 5 (Ripening): Ripening begins with petal drop from the last formed flower on the main stem. Flowering on the secondary branches may continue for some time; however, these do not usually produce productive pods. Seeds develop in the pods, and 35 to 45 days after flower opening, seed filling is complete. When physiologically mature, the seeds contain about 40 per cent moisture, the seed coat begins changing color, and seed moisture is rapidly lost at two to three per cent per day. The seeds in the first-formed pods lower on the plant ripen first at 40 to 60 days after flowering. The plant is ready to swath when 20 to 40 per cent of the seeds on a plant have a color change, the seed in the last formed pods at the top are nearing physiological maturity, are firm and the average seed moisture is about 30 to 35 per cent. *B. campestris* varieties can mature anywhere from 69 to 111 days from seeding, while *B. napus* varieties require from 88 to 133 days. Days to mature depends on date of seeding, moisture applied and the growing season climate.

CROP ROTATION

Carefully select the field for canola to avoid a buildup of disease, insects or hard-to-control weeds. Also consider volunteer growth from previous crops which may cause serious competition and seed separation problems. Herbicide residues safe for other crops may also be carried over in the soil and adversely affect canola. No one particular crop rotation will suit all circumstances. The following guide points out factors to be considered in selecting a field for canola.

GUIDE TO FIELD SELECTION FOR CANOLA CROPS

CROP	REMARKS CONCERNING CANOLA
Barley Canary seed Oats Fall rye Triticale Wheat Winter wheat	No diseases in common. Can be grown the year before or after canola. Control stinkweed, mustard, volunteer canola and other problem weeds in these crops. Keep in mind herbicide residue carryover. Barley volunteer growth may be highly competitive, reducing yields. Wheat, spring rye and triticale may have light volunteer growth not likely to cause major reductions in yield or interfere with harvest. Control herbicides available.
Buckwheat	Low risk of seedling blight and root rot for one year. Volunteer growth may be highly competitive for one year. Perennial thistles, stinkweed and

CROP	REMARKS CONCERNING CANOLA
	wild mustard not controlled and if present may build up.
Fababeans field beans Field peas Lentils Soybeans Sunflowers Potatoes	Low risk of seedling blight and root rot for one year. Risk of sclerotinia is low for three years after field peas, moderate for three years after fababeans, and high for four years after field beans, lentils, soybeans and sunflowers. High risk for one year from Sencor and Lexone as canola is susceptible to this herbicide carryover. After sunflowers there may be a high level of volunteer growth for one year. Where herbicide control is not available, perennial thistle, wild mustard and stinkweed may build up and be a problem. After potatoes fields may have a high fertility level.
Flax	Low risk of seedling blight for one year and root rot for two years after. High risk of volunteer growth with seed contamination for one year after.
Sugar beets	Low risk of seedling blight and root rot for one year. Moderate risk of sugar beet cyst nematode as canola is a host crop and should not be grown three to four years before or two years after sugar beets.
Corn	High risk of herbicide residue (Atrazine and all products containing atrazine) which may reduce stand and yield. Triazine-tolerant canola will not be affected the following year. Atrazine residues may persist for more than one year. Fertility level may be high after corn.
Alfalfa Sweet-clover	Low risk of seedling blight for one year and root rot for two years. Low risk of sclerotinia forthree years. Nitrogen release may approximate summerfallow nitrogen levels if breaking was done before June 30. Alfalfa is a high user of sulphur - soil test. High risk for herbicide residues, Princep Nine-T (Simadex, Simazine) and Sinbar which may persist for two or more years. Perennial thistles and wild mustard may build up if present.
Forage grasses	Nitrogen release may be about one-half summer-fallow levels if breaking was done before June 30.
Canola Mustard	Low risk of seedling blight for one year and root rot for two years. High risk of sclerotinia and virulent blackleg for four years. High risk of mustard volunteer growth and seed contamination for two to three years in canola. Perennial thistles, stinkweed, wild mustard, and other problem weeds likely to build up if present in the field.

GROWER CROP ROTATIONS

Previous crops to canola: 1981	1982	1983	1984	
Other*	Cereal	Cereal	Cereal	47%
Cereal	Cereal	Summer-fallow	Cereal	3%
Alfalfa	Alfalfa	Alfalfa	Alfalfa and/or cereal	6%
Summer-fallow	Sugar-Beets	Cereal	Cereal	3%
Cereal	Flax and/or Peas	Cereal	Cereal	16%
Cereal	CANOLA	Corn and/or cereal	Cereal	16%
Cereal	Cereal	CANOLA	Cereal	3%
Cereal	BEANS	SUNFLOWERS	Cereal	3%
Canola	Cereal	Summer-fallow	CANOLA	3%

* Other Crops: Cereal, sugar beets, canola, alfalfa and summerfallow

A majority of the producers used a long-term rotation appropriate for canola, i.e. canola grown after three years of cereals and/or cereals plus other crops such as flax, sugar beets or peas, with a sufficiently long interval so that they would not present a problem for canola in the rotation. The major cereal crops grown before canola were soft white spring wheat followed by utility wheat and barley. Nine per cent of the producers grew canola on a short-term rotation only one year away from canola or sunflowers or on canola stubble.

SOIL PREPARATION FOR CANOLA PRODUCTION

Few field operations are more closely related to success or failure in canola production than is seedbed preparation. Canola seedlings do not develop as quickly as cereals do to provide competition against weeds. The best defence against broadleaved weed competition is to obtain rapid germination, emergence and crop growth. Uniform, shallow seeding to moisture promotes rapid emergence and enables the crop to compete with weeds. Anything that adversely affects seed germination and emergence can cause a significant reduction in plant populations, seedling vigor, and subsequently, yield.

For canola, the seedbed should be reasonably level, uniform, well packed, and moist throughout its depth. If possible, the soil surface should have a good granular structure, with 30 to 45 per cent fine material (granules up to 1/25 inch in size), and the rest ranging up to 1/5 inch in size, with only enough larger lumps and trash to prevent wind erosion. Soil preparation for canola begins with the harvesting of the previous crop.

FALL STUBBLE TILLAGE

To help achieve the desired seedbed for canola in the spring, distribute the crop trash uniformly over the soil surface in the fall. Swathing as high as possible and leaving a stubble that still supports the swath will aid this distribution. The taller standing stubble will catch snow and protect the soil against wind and water erosion. Heavy crop residues may keep the soil cool and delay drying out enough for seeding at the optimum time in the spring. Leaving shorter stubble that will hold less snow may aid drying of fields in the spring. Unless the straw is to be baled or removed for feed or bedding, equip combines with efficient straw choppers and deflectors that widely and uniformly distribute crop residues. Harrowing with tine harrows at an angle to the combine rows on a dry day can help achieve an even spread. Crazy (oscillating) harrows work best in spreading trash evenly over the soil surface.

Never burn crop stubble. Burning reduces soil organic matter, damages soil structure and reduces availability of plant nutrients . Initially, yields of canola grown on burned stubble land may increase slightly, but burning reduces yields in the long term.

Fall tillage helps reduce excessive heavy crop residues, controls weeds, alters the soil structure, and facilitates seedbed preparation in the spring. It is preferable to fall cultivate with a heavy duty cultivator or a field cultivator which leaves some stubble to trap snow and to allow more rapid penetration of snow melt moisture. This may be more important in clay and clay loams than in loam or sandy loams. Shallow cultivation, done shortly after harvest, covers weed seeds and scattered grain and promotes fall germination of such weeds. Deep cultivation tends to bury weed seeds and scattered grain and aggravates the problem posed by dormancy in wild oats and other weeds which germinate later, when subsequent tillage lifts them near the soil surface. Excessively deep cultivation also allows for loss of critical soil moisture for spring germination. If crop residue is lodged and/or heavy, a tandem disc or disker may be a better choice in the fall. Fall plowing is sometimes necessary to bury heavy crop residue to aid in seedbed preparation in the spring. Plowed or disced fields should be left lumpy for the winter to guard against erosion.

To prevent erosion, the soil should not be worked too finely and crop residue should be maintained. Most cereal crops produce plenty of residue to combat erosion as long as it isn't incorporated by excessive fall tillage. Fall tillage with implements that leave half the soil surface covered with crop residue will usually provide protection from erosion on most soils.

Nitrogen fertilizer can be banded four to six inches deep with air flow applicators, or shanked or knifed in as anhydrous ammonia, when soil temperatures, at the four-inch depth, are less than 10°C. For anhydrous ammonia applications, clay soils should be loosened to four to five inches, and sandy soils five to six inches. Loss of ammonia can occur with shallow application in loose dry soil.

Granular trifluralin applied after an initial stubble tillage at three to four inches should be incorporated to the same depth with a tandem disc, disker or light-duty cultivator. The second incorporation should be at right angles to the first incorporation. If the first incorporation reduced trash cover so that a second incorporation would leave the soil vulnerable to erosion, the second incorporation should be left until spring. If possible, avoid fall application of soil-incorporated herbicides on soils prone to wind erosion.

Growers Soil Tillage Practices	**%**
Conventinal till	94
Minimum till	6
Zero till	0

Handling of Previous Crop Trash	**%**
Not removed	68
Baled or collected	29
Not applicable (alfalfa plowdown)	3

A majority of the growers recognized the value of returning the crop trash to the soil. It helps prevent soil erosion, returns many nutrients contained in the trash to the soil, improves the water holding capacity and infiltration rate of the soil, improves the nutrient exchange capacity and soil structure and texture.

Most growers performed at least one fall tillage operation. The majority finished their fall tillage operation by the end of the second trip. The most popular fall tillage implement was the cultivator along with the tandem disc and plow. Sixty-three per cent cultivated less than four inches deep, while 43 per cent cultivated between four and six inches, and 11 per cent tilled deeper. The majority who plowed tilled deeper than six inches. Most of the cultivators had harrows or harrows-packers. The major objectives for fall tillage operations were to manage trash and to loosen and open the soil. Twenty-one per cent applied a herbicide in the fall. Only one grower reported severe wind erosion in the period following the last tillage operation and before the first spring tillage operation.

FALL IRRIGATION

Twenty-four per cent of the growers fall irrigated applying about 75mm (3 inches) of water per acre. This brought the soil moisture content to an average 70 per cent of field capacity. When considering fall irrigation, the grower has to determine whether the existing soil moisture level is above or below 50 per cent of the available range. Where the moisture is in the lower half of the available moisture range, irrigation is recommended. Also, if the lower part of the active root zone depth is dry, irrigating is highly advisable. It is recommended that the soil moisture be raised to about the 50 per cent level when fall irrigating so that benefits from snowmelt and early spring precipitation can be obtained. Planned fall irrigation and winter/spring precipitation should reduce the need for early spring irrigation. Of course, there is always a risk associated with fall irrigation, if above average precipitation does occur, it will cause a delay in early land preparation and seeding, particularly on heavy textured soils which take longer to dry out.

FALL TILLAGE OPERATIONS

	% Doing this operation	Implement Used	
One tillage	91	Cultivator (Spikes 65%, Sweeps 35%)	52%
		Plow	29%
		Tandem disc	13%
		Noble blade	6%
A second tillage	44	Tandem disc	40%
		H.D. cultivator (spikes) & harrows	20%
		Vibra shank or field cultivator	20%
		Harrows and/or packers	13%
		Plow and packers	7%
A third tillage	18	Cultivator and granular herbicide	17%
		Granular fertilizer and herbicide	17%
		Anhydrous	17%
		Vibra shank or field cultivator	17%
		Floater	17%
		Harrows and packers	15%
A fourth tillage	6	Tandem disc	50%
		Harrows and packers	50%

SPRING TILLAGE

Uneven or weak stands usually occur where seed is either placed too deep or into dry soil. Preseeding tillage for fertilizer placement or incorporation, herbicide or trash incorporation, weed control or seedbed preparation should ensure a firm seedbed to avoid deep seeding, with moisture near the soil surface to ensure germination. The choice of implements and timing are critical in preparing a proper seedbed.

Research and grower studies indicate that preseeding tillage should be done as shallowly as possible. Any tillage operation results in rapid moisture loss to the depth of tillage. Shallow tillage promotes production of a firm seedbed that is less likely to dry out. Initial tillage should be two to three inches, deep enough to kill weeds yet still conserve soil moisture. A field cultivator (vibra shank) with harrows or disc-type field implement, followed by a rod weeder or harrows, is usually satisfactory where crop residue is light. For land with a heavy residue cover, the heavy duty cultivator with sweeps or blades plus harrows, or the tandem disc with harrows, are the most popular. Subsequent tillage operations, if required, should not be deeper than the first. Excessive tillage will pulverize the soil surface and dry out the seedbed. Where more than one tillage operation is required, the final spring tillage, just before seeding, should be done with a vibra shank or similar type cultivator, operated shallowly and followed by harrows, packers or rod weeders to firm the loosened soil. A firm seedbed permits uniform, shallow seed placement, particularly where double disc press drills are used.

Where deep tillage must be done in the spring, a soil-firming tillage operation such as rod weeding or packing should be done shortly after. If soil firming tillage is delayed, drying of the soil might occur. Where additional packing is required, it is likely to be most effective when done prior to seeding, as it helps reduce seeding depth, particularly where double disc press drills are used. Early application and incorporation of herbicides and fertilizers when the weather is cooler will help reduce moisture loss, especially if a prolonged dry spell occurs after seeding. Packing reduces moisture loss but may result in ineffective weed control under moist conditions. If seedbed moisture is usually a problem a fall application and incorporation of fertilizers and herbicides may be preferable where erosion is not a problem.

Soil Problem	Moderate %	Severe %
Crusting	21	9
Solonetzic	6	3
Salinity	12	-
Water erosion	12	-
Poor drainage	6	-
Compaction	12	3

SPRING TILLAGE OPERATIONS

	Per Cent Doing This Operation	Implement Used	%
One operation	100	Cultivator	46
		Tandem disc	24
		Anhydrous	18
		Floater	3
		Harrows	3
		Others	6
A second operation	91	Cultivator	34
		Anhydrous	27
		Granular fertilizer applicator	20
		Herbicide applicator	9
		Rod weeder	5
		Harrows	5
A third operation	67	Cultivator	60
		Tandem disc	10
		Rod weeder	10
		Harrows and/or packers	10
		Fertilizer applicator	5
		Herbicide applicator	5
A fourth operation	48	Cultivator	50
		Harrows and/or packers	25
		Fertilizer applicator	19
		Tandem disc	6
A fifth operation	15	Cultivator	40
		Rod weeder	20
		Herbicide applicator	20
		Harrow-packer	20
A sixth operation	6	Cultivator	50
		Harrow-packer	50

Using a minimum of shallow spring tillage usually results in higher yields where weed control is satisfactory and seeding is done before the soil became dry. Researchers and many growers have found that conventional tillage can be reduced and reasonably high yields still be obtained .

Results from the survey clearly showed that top growers paid close attention to their spring tillage and seedbed preparation. The majority of the growers had few soil problems, however some reported moderate to severe soil problems.

A majority of the growers did three preseeding operations primarily for trash management, weed control, applying fertilizer and herbicides, and conserving soil moisture. When considering only tillage implements and the number of tillage operations per field, the majority only tilled their fields one or two times.

Number of Tillage Operations	%
One	27
Two	46
Three 2	7

Those with three spring tillage operations had a lower average yield than those growers practising only one or two spring tillages, possibly due to the additional drying of the soil from the extra tillage operation. The main tillage implements utilized by the growers were cultivators, tandem discs and rod weeders. The most popular implement was the cultivator of which a high percentage had either harrows, harrow-packers, harrow-packer-rod weeders or packers attached. Seedbed firming operations were apparent through the use of harrows, packers and rod weeder implements.

Spring Tillage Depth	%
Up to 3 inches	30
Up to 4 inches	52
Up to 5 inches	18

The growers who practised deeper spring tillage had significantly lower yields.

SEEDBED FIRMNESS

One method of measuring seedbed firmness is to observe the depth to which the sole of a workboot sinks into the soil.

		%
1/8 to 1/4 inch	Very firm	15
1/2 inch	Firm	32
3/4 inch	Slightly firm	41
1 inch	Slightly loose	6
2 inches	Loose	6

Firming up the soil by packing reduces the size of the pores in the soil. The more packed the soil, the greater the proportion of small pores relative to large pores. Packing consolidates the soil surface and reduces the soil moisture vapor loss from the large pores of the soil. However, the soil granules should not be pulverized or packed so tightly that the supply of oxygen to the seed or seedling roots is restricted. A reasonably firm seedbed provides excellent soil moisture and oxygen for the seed, and later, the developing seedling. The highest yields were obtained from seedbeds which were slightly firm to firm. An average yield reduction of about four bushels per acre was experienced on slightly loose and loose seedbeds.

Seedbed Moisture Just Before Seeding	%	
Poor	6	
Fair	15	
Good	53	-- 79%
Very good	26	

Depth to Soil Moisture From Surface at Seeding	%	
At surface	13	
1/2 inch	32	-- 72%
3/4 inch	9	
1 inch	18	
1-1/2 inches	14	
2 inches	14	

The majority of growers maintained seedbed moisture by minimizing pre-seeding field tillage operations, conducting shallow tillage using harrows and packing implements with the tillage implements, and by firming up the seedbed.

Growers Final Rating of the Seedbed Achieved	%
Poor	0
Fair	20
Good	53
Very good	27

The question was asked, "When considering all the various farming operations and inputs under your control, and their relative importance, how high would you rate seedbed preparation compared to the other operations and inputs?"

Rating	%
Little importance	0
Medium	9
High	38 }-- 91%
Most important	53

Most of the growers in the survey believed seedbed preparation to be of major importance for canola. Research has shown the importance of fast emergence of a uniform stand which rapidly develops a large leaf surface area allowing the plants to develop more flowers producing pods and seeds per pod. Achieving an adequate plant population with early development of a maximum leaf surface area will allow the crop to reach its potential set by the nutrient availability, water resources and growing season.

The majority of the growers started their field work in April and finished the first or second week in May. This was followed shortly afterwards with seeding. The highest average yields were achieved with early seeding as shown by the average yields in brackets for each time of seeding. This agrees with research findings which generally show that canola crops respond to early seeding in southern Alberta. In order to accommodate early seeding, as much work as possible is done in the fall, and spring pre-seeding operations must start early. However, tilling the land too early only adds unnecessary risk to drying the seedbed, and, in some cases, increases the possibility of soil erosion. Most growers in the survey started their tillage reasonably early with only a short time period of tillage before seeding. *B. napus* (Argentine) canola will achieve adequate germination and emergence at soil temperatures of 5°C, however, for rapid germination and growth, *B. napus* prefers 8-15°C. *B. campestris* (Polish) canola will achieve adequate germination and growth at 7°C, but prefers 10-15°C. Soil temperature readings should be taken at seeding depth twice a day, around 8:30 a.m. and 4:30 p.m., and an average of the two readings used.

Soil Temperature at Seeding	%
3 - 5°C	6
6 - 8°C	18
9 - 11°C	38
12 - 14°C	18
Over 15°C	3
Don't know	18

Eighty-two per cent of the growers were aware of their soil temperatures at seeding, and nearly one-half used this as their main guide for seeding time.

Seeding Implement Used	%
Hoe press drill	66
Double disc press drill	25
Hoe drill (no press)	3
Double disc (no press)	3
Velmar	3

The hoe press drill was the most popular seeding implement. Research has indicated that there is no significant difference in final yield between the commonly used seeders, provided they are properly adjusted, can handle the amount of trash present and uniformly place the seed at the depth required. The seeder must open a furrow to sufficient moisture, accurately meter seed into each run, place all the seed at a uniform depth, cover the seed with soil and pack it around the seed. Where seeding is done with drills equipped with packer wheels, harrow packing after seeding has little effect on crop emergence or yields. In some cases, it might encourage heavier infestations of weeds such

Time of Spring Tillage Operations and Seeding

	Time of first tillage (%)	Time of last tillage (%)	Time of seeding (%)
1st half of April	33	4	--
2nd half of April	37 }- 91%	27 }- 78%	15 } - (52 bu/ac)
1st week of May	21	33	12
2nd week of May	6	18	38 - (49 bu/ac)
3rd week of May	3	15	26 - (48 bu/ac)
After May 21st	--	4	9 - (37 bu/ac)

as stinkweed by packing the soil around the weed seeds. Furrows left by the packer wheels of the drill tend to protect emerging seedlings against drifting soil on erosion-prone soils. Harrow packing after seeding of such soils makes them more erodible and exposes the emerging seedlings. Harrowing may also increase the depth of soil the seedling must emerge through by levelling the ridges over the seed furrows. Very few of the top growers used post-seeding field operations.

Seeding Depth	%	
1/4 - 1/2 inch	15	
1/2 - 3/4 inch	24	-- 73%
3/4 - 1 inch	34	
1 - 1-1/4 inch	6	
1-1/4 - 1-1/2 inch	6	
Over 1-1/2 inches	15	

A majority of the growers seeded shallow, within one inch of the soil surface. The growers who seeded shallow and placed the seed 1/4 to 1/2 inch into soil moisture had higher average yields than growers who seeded shallow just to soil moisture or who seeded deep into soil moisture. Growers who seeded shallow in seedbeds which had dried to 1.5 to 2 inches and irrigated the crop up obtained similar yield results to those who seeded shallow into moisture.

Canola is small seeded and very sensitive to seeding depth. Seeding depth greatly influences the number of seedlings that emerge, their rate of development and the crop's final yield. Seed sown shallow into moisture rapidly germinates and emerges, as the soil temperatures near the surface warm up first as they are strongly affected by air temperatures during the day. Deeper seeding (over 2 inches) results in poor emergence; reduced root, seedling and plant growth; delayed maturity; seedling disease, and reduced yields.

B. napus varieties are larger seeded than *B. campestris* varieties and can be sown deeper (up to 1.5 inches) without suffering the germination, emergence and yield reductions that *B. campestris* exhibits when sown deeper than one inch.

Number of Days From Date of Seeding to Seedling Emergence	%	
4 to 9 days	52	-- 88%
10 to 13 days	36	
14 to 17 days	12	

The crops of the majority of the growers emerged early after seeding. Those fields which took longer to emerge were either dry at seeding depth, had slightly loose to loose seedbeds, were sown deeper or were crusted. These were the same causes given for the development of uneven or patchy stands, especially dry seedbeds and seeding too deep. Preservation of seedbed soil moisture through minimum spring tillage, obtaining a firm seedbed, doing as many field operations in the fall as possible, and controlling winter annual and other weeds are important factors in achieving a good seedbed and overcoming the major identified problems in obtaining a uniform, even, rapidly emerging, vigorous seedling stand. Surface crusting can be reduced by maintaining as high an organic matter level in the surface soil as possible. In fields where crusting is a problem, previous crop trash should not be removed, burned or buried deeply by implements such as the plow or disc-type machines. Manure can be helpful on these soils.

Class of Seed Used	%
Pedigreed	95
Canada No. 1	5

Ninety-five per cent of the growers purchase and use certified seed treated with a dual purpose fungicide-insecticide every year they grow canola. Germination tests indicated germination was between 80-100 per cent. The growers realized the value of a guaranteed level of genetic purity, germination, freedom from disease and weed seeds, which can only be obtained from pedigreed seed. Good seed contributes to higher yields.

Seeding Rate	%	Range in Yields (bu/ac)
4 lb or less/acre	6	35-46
4 to 5 lb/acre	12	42-60
5 to 6 lb/acre	53	32-67
6 to 7 lb/acre	23	40-62
8 or more lb/acre	6	50-69

Average Plant Population Density	%	
Heavy	12	-- 82%
Medium	70	
Light	15	
Don't know	3	

A majority of the growers seeded at 5 or more lb/acre and achieved a medium to heavy plant population density. Canola is a very flexible crop in that variations in seeding rate, or plant populations

over relatively wide ranges, normally have very little effect on yield. This can be seen in the range of yields with 60 or more bushels per acre reached for all seeding rates except the four pounds or less per acre rate. The general recommended seeding rate in southern Alberta for *B. napus* varieties is 5 to 7 lb/acre, and for *B. campestris* varieties 4 to 6 lb/acre. With shallow seeding into an above-average seedbed which is firm, moist and warm, about 60 to 80 per cent of the seed sown will normally produce viable plants. The seeds which do not germinate or emerge are mechanically stopped by the soil or killed by disease. With an above-average seedbed, a 5 lb/acre seeding rate of *B. napus*, which averages about 115,000 seeds per pound, would place about 13 seeds per square foot, of which 8 to 10 would develop viable plants. However, under average to below average seedbed conditions, where only 40 per cent of the seed may produce plants, about five plants per square foot would result, which may not be a high enough density to hit top yields. For these conditions, the higher seeding rate will assure at least the minimum plant population required. Growers should aim at establishing plant populations of 7 to 17 per square foot. With a 6-inch drill row spacing, this would require a stand of 11 to 25 plants per yard of drill row.

Cross Seeding (seeding 1/2 the seed in one direction, the remaining 1/2 at 90° to the first)	%
No	94
Yes	6

Under most conditions, the normal 6 to 7-inch row spacing is adequate to obtain high yields. However, research at Beaverlodge, Edmonton and Winnipeg has shown yield increases with narrower drill row spacings. To achieve a greater distribution of plants, some growers have cross-seeded. These growers report faster stand establishment and better competition against weeds.

FERTILIZER REQUIREMENTS OF CANOLA

On a General Basis, How Often Are Fields Soil Tested?	%
Every year	58
Every 2nd year	15
Every 3rd year	15
Every 5th year	6
Never	6

Depth of Soil Sample Taken for Test	%
0 - 6 inches	100
6 - 12 inches	76
12 - 24 inches	52
24 - 36 inches	3

Generally most growers test their soils on a frequent basis to aid in their fertilizer application decisions. Fifty-eight per cent soil tested their canola fields. These growers believe that through the use of soil test results, a farmer can better ascertain the proper levels of fertilizers to apply to maximize yields. Under irrigation significant quantities of nitrogen can be leached below the 6-inch level. In order to account for this extra nitrogen, 6-12 and 12-24 inch samples must be taken. Sampling deeper than 6 inches greatly improves the reliability of nitrogen and sulphur test results. If soil problems such as salinity or solonetzic soil are suspected, 6-12 and 12-24 inch samples should be taken.

Nitrogen Applied: lb/acre	%	Range of Yields	Average Yield
Less than 50	3	35	35
50 to 70	8	33 to 40	38
70 to 90	23	32 to 67	47
90 to 110	38	40 to 60	48
110 to 130	22	45 to 60	55
170 to over 180	6	60 to 69	65

A 50 bu/acre canola crop will remove about 170 lb/acre of nitrogen from the soil; however, only 105 lb/acre of nitrogen will be removed from the field with the seed. Sixty per cent of the growers applied between 90 to 130 lb/acre of actual nitrogen. If soil test results indicate low soil nitrogen (less than 20 lb/acre), then up to 150 lb/acre of actual nitrogen can be applied. The rate is decreased as nitrogen soil test results increase. (Source - Alberta Agriculture Research).

Soil Test Results	Applied Nitrogen
Up to 20 lb/acre	150 lb/acre
30 lb/acre	140 lb/acre
50 lb/acre	120 lb/acre
75 lb/acre	110 lb/acre
100 lb/acre	80 lb/acre

Form of Nitrogen Applied	%
Liquid	6
Granular	29
Anhydrous	65

Time of Nitrogen Application	%
Fall	6
Spring	94

Placement of Applied Nitrogen Fertilizer	%
Broadcast	27
Deep-banded	68
Part deep-banded, remainder fertigated	6

Ninety-four per cent of the nitrogen was deep-banded in the spring mainly in the anhydrous form. Only 27 per cent of the nitrogen fertilizer was broadcast-incorporated. Canola is very sensitive to nitrogen fertilizers applied with the seed, especially where the seedbed is relatively dry. Generally, the rate of nitrogen should be limited to a maximum of 10 lb/acre when placed with the seed.

Canola response to applied nitrogen fertilizer will depend on when and how the fertilizer is applied and moisture available to the plants during the growing season. A strong interaction occurs between nitrogen and water. The full effect of favorable moisture conditions from irrigation cannot be realized until adequate nitrogen has been applied to the canola and vice versa. Growers applying high water rates with wheel-move or centre-pivot systems achieved average yields of 58 bu/acre and used similar nitrogen fertilizer rates to those growers who averaged only 44 bu/acre but applied much lower rates of water. Yield differences were apparent but not as great between those growers applying similar water rates and high versus medium nitrogen fertilizer rates.

Although most of the nitrogen fertilizer was applied in the spring in 1985, it is becoming more popular in the Brown soil zone to apply nitrogen in the ammonia form by deep banding in the late fall. This saves valuable spring time, facilitating earlier seeding and helps to conserve seedbed moisture and firmness. Research has shown this to be a valid alternative to spring application. Losses of nitrogen through denitrification and leaching are not usually very great in the Brown soil zone when anhydrous ammonia or urea forms are deep banded. The risk of loss must be weighed against the advantage of fall application. Fall broadcast-incorporated urea fertilizer is not recommended, as losses are usually great (20-50%) in southern Alberta. If the nitrogen cannot be deep banded then only the 34-0-0 type of nitrogen should be used for fall broadcast and incorporation.

Phosphorus Applied (P_2O_5 lb/acre)	%
None	6
16 to 20	6
21 to 30	30
31 to 40	12
41 to 50	6
51 to 60	21
61 to 70	9
71 to 80	6
Over 100	3

A wide range of phosphorus fertilizer application rates were utilized by the growers. Canola generally responds favorably to phosphorus fertilizer on soils that are low in available phosphorus. The maximum response to nitrogen fertilizer cannot be obtained when phosphorus and other essential nutrients are in short supply, and the response to added phosphorus fertilizer can also be limited if available soil nitrogen is at low levels. High rates of residual phosphorus are common in many southern Alberta irrigated soils. This has resulted from high rates of phosphorus having been applied on specialty crops over the last 40 to 50 years. This residual phosphorus reduces the importance of phosphorus being applied with the seed, obscures the effect of deep banding, and reduces the application requirements. Rates above 30 lb of P_2O_5/acre are only necessary when soil tests indicate a low phosphorus level and vice versa. (Source - Alberta Agriculture Research).

Phosphorus Recommendations at Various Soil Test Levels:

Soil Test Results (P_2O_5 lb/acre)	P_2O_5 Recommendation lb/acre
Over 50	10
40 to 50	15
30 to 40	20
20 to 30	30
10 to 20	40
0 to 10	50

Soil Phosphorus Levels Based on Soil Test Analysis or Growers' Own Estimates:

	%	Ranges of P_2O_5 Applied (lb/acre)
Low	29	23 - 55
Medium	32	18 - 75
High	21	0 - 65
Don't know	18	0 - 105

Seventy-eight per cent of the growers who applied more than 100 lb/acre of nitrogen fertilizer and rated their soil phosphorus levels as medium to high also applied high rates of phosphorus fertilizer. All nutrient requirements must be present in proper proportions for maximum yields. Increased fertilization will not increase yields if the added nutrients are not required.

Form of Phosphorus Used	%
Liquid	6
Granules	94

Time of Phosphorus Application	%
Fall	3
Spring	97

Placement of Applied Phosphorus Fertilizer	%	
Broadcast-incorporated	13	
Deep banded	16	
With the seed	48	-- 71%
Part deep banded, remainder with seed	23	

A majority of the growers applied all or some of the phosphorus with the seed. With low soil phosphorus levels the most efficient means of applying phosphorus is drilling it in with the seed. However, no more than 20 lb/acre of P_2O_5 should be placed with the seed when sown with a double disc drill under average moisture conditions, and no more than 28 lb/acre under very good moisture conditions. In applications with a disker, air seeder or hoe drill, 28 lb/acre of P_2O_5 may be seed placed. Higher rates of phosphorus reduce seedling emergence and yield potential. Where higher rates of P_2O_5 are required, it can be banded away from the seed. This results in little damage to germination and emergence, and larger yield responses to considerably higher rates of applied fertilizer where required. The phosphorus can be applied in the same band with nitrogen (double shooting). When nitrogen and phosphorus are placed together in a band they are usually more effective than when broadcast and mixed into the soil. Retaining some of the phosphorus fertilizer for seed placement may be beneficial on very low testing phosphorus soils, when surface moisture is good and when cool, wet conditions prevail in the spring.

Potassium Applied (lb/acre)	%
None	82
Under 10	3
21 to 30	12
91 to 100	3

Very few of the growers applied potassium fertilizer. The growers who used potassium fertilizer applied a granular form in the spring mainly by deep banding. Most soils in Alberta, except sandy or organic soils, contain large amounts of potassium. Canola responses to potassium fertilizers are not large on soils with moderately low available potassium. However, on very deficient potassium soils a marked yield increase may result from potassium fertilizer application. Research on many sites in southern Alberta has not indicated a need for potassium. If the soil test results (0-6 in level) show:

a) over 300 lb/acre - potassium should not normally be applied.
b) between 200-300 lb/acre - a test strip could be tried.
c) under 200 lb/acre - a response may be possible from the addition of potassium.

Sulphur Applied (lb/acre)	%
None	88
Under 10	6
16 to 20	3
21 to 25	3

Very few of the growers applied supplemental sulphur. Sixty-seven per cent of those growers that applied potassium also applied sulphur in a granular form in the spring mainly by deep banding. Canola needs about 30 lb of sulphur per acre to produce a 50 bu/acre crop. Research has shown that irrigation water contains about 30 lb of sulphur for every 12 acre inches applied. Therefore, even ignoring the soil sulphur supply, adequate sulphur may be supplied through the irrigation water.

MICRONUTRIENTS USED

Most growers (97%) were not using micronutrients. The type and the need for micronutrient appliocation should be based on plant tissue analysis test results. Recent research has indicated, through tissue analysis, that micronutrients are rarely deficient in our soils. Norms, or values, established mainly in the United

States for micronutrients, are not applicable to Alberta soils. Leaf tissue analysis is the best indication of micronutrient deficiencies rather than soil test results at this time. Tissue analysis shows what the plant is actually receiving from the soil. Alberta soils testing low in micronutrients, compared to established norms, have produced plants that have not been low in micronutrients when tissue analyses were performed. More research is needed in this area.

IRRIGATION OF CANOLA

The weight of water required to produce a canola crop may be a thousand times the weight of the crop itself. The plants remove water from the soil to transport nutrients from the soil to the green plant tissue where they are used in photosynthesis. Carbohydrates, the product of photosynthesis, are conveyed in water solution to storage organs where the water simply evaporates through the stomata (tiny pores in the leaves). This evaporation process, called transpiration, absorbs heat, cools the plant and prevents the build up of injuriously high temperatures. Water is also lost directly from the soil surface through evaporation. The combination of these two losses of moisture is known as evapo-transpiration (ET).

Solar radiation is the most important climatic factor which influences ET. Solar radiation is the source of energy necessary to transfer water from a liquid to the vapor phase in both plants and soil. Other factors which also influence ET are air temperature, relative humidity, precipitation and wind.

The influence of the crop on ET is primarily through stage of growth and amount of ground cover. When the crop is young and not completely covering the ground, the daily rate of ET will be less than the maximum rate (between 1.7 - 3.2 mm/day). When the crop is actively growing, providing full ground cover, and adequately supplied with soil moisture, ET will be at a maximum for the current weather conditions (7.7 mm/day). As the crop ripens, its ability to transmit water from the soil declines and ET decreases.

In the irrigated areas of Alberta, adequate soil moisture is required during the crop growing season to produce optimum yields. Seasonal water requirements vary with the variety of canola grown. *B. napus* varieties have a seasonal moisture requirement and growing season similar to that of irrigated soft white spring wheat.

Total Water Use (*B. napus*)

June 10	100 mm - 4 in.
July 5	200 mm - 8 in.
July 15	300 mm - 12 in.
July 30	400 mm - 16 in.
Aug. 15	480 mm - 19 in.

B. campestris varieties have a lower seasonal moisture requirement and shorter growing season than the *B. napus* varieties. *B. campestris* varieties have a seasonal water requirement of 430 mm.

The highest yields of canola will be obtained when adequate soil moisture is maintained throughout the growing season. Adequate soil moisture can be defined as maintaining soil moisture depletion of 50 per cent or less of the available soil moisture in a 1.0 m root zone. Availability of soil moisture for canola use varies with soil texture.

Loamy sand - find sandy loam	- 25 to 40 mm/0.3 m
Loam	- 50 to 60 mm/0.3 m
Clay loam - silty clay loam	- 55 to 65 mm/0.3 m
Sandy clay - clay	- 50 to 58 mm/0.3 m

The actual root zone used by canola will vary from 5 to 6 cm at germination to at least 1.0 m during the flowering and seed production. As the root zone varies during crop development so does the moisture extraction pattern of the crop. When the crop is fully developed, 40 per cent of the moisture available in the root zone is extracted by the roots in the first quarter of the effective root zone depth, 30 per cent in the second quarter, and 10 per cent in the fourth quarter. This extraction pattern corresponds more or less to the ratio of the mass of roots in that zone as it compares to the total root zone. Root development gradually reaches maximum depth about the time flowering occurs after which the plant either maintains or expands its root system only slightly. Therefore, canola obtains nearly 70 per cent of its total water requirement from the top half metre of root zone.

Canola builds the plant structure it needs for optimum yields early in the growing season. Soil moisture should be maintained at less than 50 per cent depletion of the available moisture in the root zone. If adequate soil moisture exists in the lower half of the root zone, soil moisture depletion may

drop to 70 per cent of available moisture in the upper half of the root zone before an irrigation is required. A firm, moist seedbed will provide uniform seed germination and rapid seedling growth. Adequate soil moisture at the seedling and elongation stage promotes the development of a strong, healthy plant, less subject to lodging, with a maximum amount of leaf growth by the end of June. Through the process of photosynthesis, leaves provide the predominant source of food for seed development. Management practices that increase leaf development and prolong leaf life will help to increase seed quality and quantity. Where adequate soil moisture conditions exist throughout the growing season and sufficient quantities of plant nutrients are available for crop use, optimum yields can be obtained.

Irrigation Treatments:	**Yield (bu/acre)**	
	Fertilized	**No Fertilizer**
No irrigation	19.5	20.3
Irrigated to stem elongation	22.5	23.0
Irrigated to early pod formation	28.5	30.5
Irrigated to pod ripening (first seed turning brown)	48.0	39.5

Maintaining good soil moisture conditions throughout the root zone lengthens the flowering period and increases the number of seeds per pod, seed weight, and in some cases, seed oil content. The maintenance of adequate soil moisture has the tendency to lengthen the crops days-to-mature by up to 10 days. Depending on seeding date, crop variety and soil moisture conditions, the last irrigation will vary from the middle of July to the first week in August. Irrigating any later than this may cause vegetative growth to continue, delaying harvest, possibility of crop lodging, and possible frost damage, all lowering quality and quantity of seed produced.

The critical growth period for canola is from the flowering stage to pod filling. Limiting watering during this period will result in fewer pods, early leaf loss and reduced yields. Since canola flowering will cover up to a 30 day interval with a potential crop use of 200 mm of water, it is almost impossible to avoid irrigation during this time period if the desirable soil moisture levels are to be maintained.

People using centre pivot irrigation systems generally have no problems with irrigating when they want to because of the clearance the system has between the bottom of the pipe and the height of the crop. People using side wheel roll systems to irrigate canola crops need to pay closer attention to soil moisture conditions and crop development. Since this system is limited by crop height, a final irrigation during the early flowering stage of the crop will be required, even though soil moisture conditions may be above the 50% allowable depletion level. This irrigation will ensure sufficient water is available for complete development.

Knowing when to irrigate and how much water is needed to refill the root zone at any time during the crop growing season, depends on the following factors:

1. The water holding capacity of the soil.
2. Rate of moisture use (ET) and effective rooting depth of the crop.
3. Desired moisture level to be maintained for optimum yield and quality with minimum number of irrigations during the crop growing season.

Once the amount of water available for crop use has been determined (the value between field capacity and 50% depletion level), dividing by the peak use rate (ET), the time in days before the next irrigation can be calculated (this is known as the irrigation interval).

$$\text{Irrigation interval} = \frac{\text{allowable depletion (mm)}}{\text{peak use rate (mm/day)}}$$

This irrigation interval is for a mature crop growing in midseason, using moisture at its maximum rate. This interval can be calculated for other times during the growing season as well, but it will be different. For example, a young crop will have a shallower rooting depth and will use less moisture each day than a mature crop. This will affect the interval required between irrigations.

The same principle can be used to predict the number of days until the next irrigation is required on any day during the growing season. To do this the actual level of soil moisture or actual depletion must be determined. Using the daily moisture use rate and the usable moisture reserve in the soil it

gives the number of days until the next irrigation is required.

$$\text{Moisture Left (Days)} = \frac{\text{Allowable Depletion - Actual Depletion}}{\text{Actual Use Rate}}$$

To determine the actual depletion at any particular time, the soil moisture must be determined or monitored during the growing season.

To manage the irrigation correctly it is therefore necessary to know the amount of water available to a crop and the water use rate by that crop.

The decision to irrigate in the fall depends on what soil moisture conditions are after the crop has been harvested and whether or not water is available for a final irrigation. A final irrigation may be required to ensure adequate sub-soil moisture conditions are adequate for next year's crop, or a final irrigation may be required to leach any salts that may have risen to the surface during the previous crop growing season. In any case, soil moisture conditions need to be determined for the root zone before water is applied to ensure that over irrigation does not occur and that sufficient room is left in the root zone for any precipitation that falls over winter. For fall irrigation to be effective, the root zone only needs to be refilled to the 50% level of the available moisture range.

A simple and accurate method a person can use to determine soil moisture content is the "feel method". By squeezing a handful of soil firmly, one can determine the amount of moisture present in the soil just by the feel and appearance of it. By soil sampling each quarter of the root zone, one can calculate the amount of moisture present in the entire root zone and by knowing what stage the canola crop is at, consumptive use can be determined, and one can then estimate when the next irrigation needs to take place.

PRACTICAL INTERPRETATION CHART FOR AVAILABLE SOIL MOISTURE

		Feel or Appearance of Soils		
	PER CENT OF AVAILABLE MOISTURE REMAINING	SANDY LOAM	LOAM	CLAY LOAM
DO NOT IRRIGATE	At Field Capacity 100	Upon squeezing, no free water appears on soil but wet outline iof ball is left on hand.	Same as sandy loam.	Same as sandy loam.
	75 to Field Capacity	Forms a weak ball, breaks easily, will not slide.	Forms a ball and is very pliable. slicks readily if relatively high in clay.	Easily ribbons out between fingers, has a slick feeling.
IRRIGATE SPEC. CROPS	50 to 75	Tends to ball under pressure but seldom will hold together.	Forms a ball, somewhat plastic, will sometimes slick slightly with pressure.	Forms a ball, will ribbon out between thumb and forefinger.
IRRIGATE	25 to 50	Still appears to be dry, will not form a ball with pressure.	Somewhat crumbly, but will hold together from pressure.	Somewhat pliable, will ball under pressure.
	0 to 25	Dry, loose, single-grained, flows through fingers.	Powdery, dry, sometimes slightly crusted but easily breaks down into powdery condition.	Hard, baked, cracked. Sometimes has loose crumbs on surface.

Ball is formed by squeezing a handful of soil firmly

Water Application:

System	Number of Applications	Water Amount	Average %	Yield (bu/ac)
Wheel move	1	Low (3-4")	10	33
	2	Medium (7-9")	70	43
	3 - 4	High (10-14")	20	57
Pivot	6	Low (7-10")	6	32
	3 - 9	Medium (10-13")	44	45
	8 - 12	High (15-20")	50	59
Flood	2 - 3	High (9-14")	100	52

Type of Irrigation System	%
Centre pivot	56
Wheel move	32
Flood	12

Indicators Used to Decide When to Irrigate	%
Soil moisture by feel	56
Stage of crop	29
Irrigation scheduling program	21
When priority call on equipment and labor allows	15
Soil moisture level by instrument	12
Crop appearance	6

Fifty-six per cent of the growers grew canola under centre pivot systems. High average yields were achieved under all three irrigation systems when adequate water was applied when required by the crop. Very little rainfall occurred in June or July for the majority of the growers. Growers applying high water amounts with wheel move systems first irrigated at the seedling stage and finished at mid to late flower. Growers with centre pivots applying high water amounts started their pivots at the seedling stage and made a circle every week from the end of May to the first or second week of August. The pivot growers who applied irrigation up to two weeks before swathing had much higher yields than those who quit irrigating early to ripen off the crop. Flood irrigation began at the rosette to bud stage in June and finished in July at the late flower or pod set stage.

WEEDS OF CANOLA

Weeds can be one of the most limiting factors in canola production. Among the more troublesome weeds that are not controlled by herbicides in a normal canola crop are the closely related cruciferous weeds:

- Wild mustard	- Flixweed
- Stinkweed	- Wormseed mustard
- Shepherd's purse	- Hare's-ear mustard
- Ball mustard	- Common peppergrass

Other hard or expensive to control weeds in canola are:

- Canada thistle	- Sow thistle
- Cleavers	- Green smartweed
- Lady's thumb	- Quackgrass

Weeds result in significantly reduced yields through competition for light, moisture and nutrients. Yield losses depend on the kind of weed, weed populations, time of emergence of weeds and crop, and the timing of control. Canola is not a strong weed competitor in the early growth stages, as it is slow growing and slow to cover the ground. The time of emergence of the weeds will have a major effect on crop yield losses. If weeds emerge before the crop, there are greater yield losses than if the crop emerges first. After canola becomes established with a large rosette, there are few weeds that can survive the intense competition. Weeds emerging 7-10 days after the crop have a greatly reduced ability to compete with the crop.

Important of Weediness at the Early Seedling Stage	%	
Low importance	3	
Medium importance	9	
High importance	41	-- 88%
Most important	47	

Most growers believed that an essentially weed-free seedling stand is of great importance in canola. Shallow seeding is an important factor in obtaining rapid emergence and ground cover to compete with weeds. Shallow seeding is only possible when there is sufficient moisture near the surface to support germination.

Most Common Weeds	**%**		**%**
Wild oats	50	Stinkweed	21
Canada thistle	47	Pigweed	12
Volunteer cereals	26	Sow thistle	9
Wild millet	24	Others	3-6

Other weeds were quackgrass, wild mustard, flixweed, lamb's quarters, Russian thistle, field bindweed and lady's thumb.

Fall Applied Herbicides	**%**
None applied	79
Trifluralin	15
Triallate	6

Spring Pre-emergence Applied Herbicides	**%**
None applied	44
Trifluralin (liquid)	35
Trifluralin (granules)	12
Triallate	9

Post-emergence Applied Herbicides	**%**
None applied	26
Lontrel	35
Poast	56
Hoe Grass	3

Used a Wild-Oat Herbicide:

Triallate	**Trifluralin**	**Post-emergence**	**Total**
15%	62%	59%	136%

The major weeds were wild oats, Canada thistle, volunteer cereals, wild millet and stinkweed. One hundred per cent of the growers used a wild oat herbicide, however, thirty-six per cent either incorporated triallate or trifluralin or both and still applied a post-emergence wild oat herbicide to kill wild oat escapes. Thirty-five per cent of the growers used Lontrel for Canada thistle control.

Weediness of Crop After Herbicides	**%**
None	26
Light	71
Moderate	3
Heavy	0

Most of the growers were aware of their weed problems, took action to control the weeds and achieved an almost weed-free crop and high yields.

INSECT PESTS OF CANOLA

From emergence to harvest, canola crops are attacked by a number of insect pests. Fields should be examined daily during the seedling stage and regularly thereafter. By recognizing which insects found in the crop are capable of causing major losses, and which are of no economic importance, growers can avoid unnecessary and costly treatments. The timely application of insecticides, combined with cultural controls will avert major damage.

Insect Problems	**%**
None	47
Grasshoppers	21
Fleabeetles	12
Cutworms	12
Bertha armyworm	4
Alfalfa looper	4

Insect Control Method	**%**
None	15
Seed treat	32
Granules with seed	68
Insect spray	24

Frequency of Field Inspection	**%**
1 - 3 days	41
4 - 7 days	41
8 - 14 days	18

Yield Losses From Insects	**%**
None	85
5% or less	15

Eighty-five per cent of the growers used a seed dressing or insecticide granules with the seed. Forty-one per cent were aware that a threshold level of infestation must be reached before spraying for grasshoppers, cutworms, bertha armyworm or loopers is justified. This was evident by the fact that 41 per cent indicated an insect presence but only 24 per cent sprayed. If potentially harmful insect infestations are observed early through field inspection, they can normally be easily controlled.

DISEASES OF CANOLA

Diseases affect the pods, stems, leaves and roots of canola crops grown in Alberta every year. Occasionally this results in serious losses to the grower. Different diseases can attack the crop at any time from seeding to maturity. Disease severity varies with the year and location, and is greatly influenced by farming practices and environmental conditions. Being able to identify disease problems that are potentially important will allow growers to adopt management practices that reduce economic losses.

Diseases Reported by Growers	**%**
None	68
Damping-off	3
Sclerotinia stem rot	29

Per Cent of Plants Infected by Sclerotinia Stem Rot	**%**
No problem	71
0 - 10%	23
10 - 20%	3
20 - 30%	3

Yield Loss Due to Sclerotinia Stem Rot	**%**
No problem	71
Light (under 5%)	20
Moderate (5 - 15%)	9

Disease Control Methods	**%**
No control	26
Seed treat	68
Fungicide spray	15

Most growers reported that diseases were not a problem, however, 29 per cent reported sclerotinia stem rot. A 1985 disease survey of irrigated canola fields in southern Alberta found sclerotinia in 70 per cent of the fields, ranging from 57 per cent trace to light, 35 per cent moderate, and severe in eight per cent . The low percentage of infected fields reported by survey growers may be related to the ability of the growers to recognize low levels of the disease.

Sclerotinia was reported mainly under centre pivots. This trend has been noted over the years. Pivot systems can create more favorable conditions for the disease as they generally apply more water during the bud to late bloom stages when sclerotinia infection occurs. Both the canopy and the top layer of soil remain moist for a much greater percentage of the time under pivots. The soil remained wet for the duration of flowering in 95 per cent of the pivot fields, allowing ideal conditions for the growth of spore-producing apothecia. Thirty-two per cent of the pivot fields had apothecia while none were seen in the wheel move fields. Thirty-five per cent of the growers did not know what apothecia were or whether they were in their fields. It is important to evaluate fields for sclerotinia stem rot before flowering to determine whether or not a fungicide should be applied. Of the growers who found apothecia, 60 per cent got sclerotinia in their canola crop. Sclerotinia is very persistant in that 80 per cent of the growers who had sclerotinia in previous canola or other crops, had it again in 1985.

The growers that applied the most water also reported the most disease but also achieved the highest yields. Fields with a wet canopy every day from the start of flowering stood a 43 per cent chance of getting sclerotinia, twice that of canopies that dried out. Decreasing irrigation during flowering will result in lower crop yields, however, if the pivot can put the water on in fewer passes, the level of infection may be reduced. For best sclerotinia control, a fungicide should be applied at the 20 - 30 per cent flowering stage. The growers who sprayed a fungicide did so for good reasons: 83 per cent had sclerotinia previously; 67 per cent had constantly wet canopies during flowering, and 83 per cent found apothecia in their fields. The fields which were sprayed resulted in none to light infection levels except for one field with 20 - 30 per cent infection.

SWATHING CANOLA

As a high yield canola crop approaches maturity, it may ripen very quickly. To determine when a field of canola is ready to swath, examine plants from different parts of the field. The stage of maturity in an evenly maturing field will vary from plant to plant and area to area within the field. When examining the plants, take into account varying soil types, low lying areas, available soil moisture and exposed ripening areas. Begin to inspect every two to three days when the crop changes from green to yellow-green.

The color of the seed is more important than the overall color of the field in determining the stage of maturity. The best time to swath for optimum seed yield and quality is when all the seeds

contain about 30 to 35 per cent moisture. The color of the seeds is a good indicator of seed moisture content. Seeds in all pods on a plant complete filling (physiological maturity) at about 40 per cent moisture and then slowly turn from green to light yellow, or reddish brown to brown, depending on the variety. Once filled, the seeds rapidly lose moisture at about 2 to 3 per cent or more per day, depending on the weather.

Examine only those pods on the main stem. Seeds in pods on the bottom third of the main stem were formed earlier and will turn color much sooner than seeds in the pods on the top third of the plant. When seeds in the bottom pods turn color, seeds in the top, last-formed pods are filled or nearly filled. When the overall moisture content of the seed from the total plant averages 30 to 35 per cent, about 30 to 40 per cent of the seeds in pods on the main stem only will have changed color or have started to change color. Seeds with only small patches of color should be counted as color changed. Most of the seeds will be firm, and roll, as opposed to break, when pressed between forefinger and thumb. In lodged crops, the seed on the upper side of the stem will mature ahead of that shaded from the sunlight but in the same section of the stem.

Under these conditions, swath when about 40 to 50 per cent of the seed in the exposed pods has turned color.

Swathing earlier at a higher moisture content may result in immature, shrivelled seeds and lower yields, especially if very hot and dry, windy weather occurs shortly after swathing. On the other hand, swathing later when seed moisture is much lower, around 20 per cent, results in fluffy windrows susceptible to blowing, increased shattering and increased frost risk.

Determination of When to Swath	**%**
Per cent seed color change	47
Color of crop	44
Other	9

Seed Moisture Content at Swathing	**%**
15 - 30%	21
30 - 40%	41
Over 40%	3
Don't know	35

Per Cent Seed Color Change at Swathing	**%**
Up to 25%	24
25 - 40%	42
40 - 50%	18
Over 50%	6
Don't know	10

Frosts Before or Shortly After Swathing	**%**
None	74
Yes	26

Swath Rollers Used	**%**
Yes	97
No	3

Most growers used seed color change or color of crop to decide when to swath and swathed after 25 per cent seed color change. Of the 26 per cent reporting a frost either before or shortly after swathing, 38 per cent of these reported a green seed problem after harvest. Of the 24 per cent who swathed the crop with less than 25 per cent seed color change, 12 per cent had a green seed problem after harvest. Most growers used swath rollers and cut in circles around the field with cuts of 14 to 18 feet. Very few reported yield losses from shelling before or during swathing.

COMBINING AND STORAGE

Canola in the windrow is ready to pick up and thresh when the seed temperature and moisture content have dropped to a safe storage level and most seeds are mature with no green color. If there are some green seeds, a few more days in the windrow is probably all that is needed, unless they were frost damaged. Green seeds may ripen in the windrow but they do not cure significantly once they are combined. Before combining, use a crush stip to make sure the seeds are not green inside. If wide swathers are used on tall, heavy crops, the result is very large windrows which take a longer time to cure, especially at the centre of the windrow. Bunching in the windrows also may contribute to a green seed problem as the crop dries out and cures unevenly. Canola is considered dry for marketing at 10 per cent moisture content. However, 8 to 9 per cent moisture at temperatures below 20°C are necessary for long term storage.

Seed Moisture Content When Harvested	**%**
Below 8%	21
8 to 10%	71
Over 10%	8

Level of Dockage	**%**
0 to 4%	26
4 to 6%	65
Over 6%	9

Grade Achieved	**%**
CR No. 1	88
CR No. 2	8
CR No. 3	9

Most growers combined their canola with less than 10 per cent moisture and low dockage and achieved a number one grade. The grade reductions occurred mainly because of green seed problems either from frost damage or early swathing.

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